

**POST-CLEANUP VERIFICATION REPORT**

**AUSTIN AVENUE RADIATION SITE,  
34 LEWIS AVENUE**

**February 1997**

**Prepared by**

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**for**

**U.S. Army Corps of Engineers  
Baltimore District**

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## **1 OBJECTIVE OF VERIFICATION REPORT**

The primary objective of this verification report is to provide independent verification that the remediation contractor decontaminated the property at 34 Lewis Avenue such that it complies with the U.S. Environmental Protection Agency (EPA) cleanup criterion for radium-226 in soil and that the property is radiologically suitable for unrestricted use. This report includes the results of the verification survey and documents that the property has been decontaminated to the radiological criteria established for the Austin Avenue Radiation Site.

## **2 PROPERTY BACKGROUND**

The Austin Avenue Radiation Site includes approximately 40 parcels of land in Lansdowne Borough, Aldan Borough, East Lansdowne Borough, Darby Borough, and Upper Darby Township, Delaware County, Pennsylvania. A map of the Philadelphia area showing East Lansdowne is provided in Figure 1. These parcels are all within a 2-mile radius of the former W.L. Cummings Chemical Company radium-refining operation in Lansdowne. They were contaminated with radium and thorium because waste tailings from past refining operations were used in building construction and renovation during the early 1900s. Twenty-one of these parcels are on the National Priorities List of the EPA and are being remediated in accordance with the EPA Record of Decision, effective June 27, 1994. The remedial actions selected for these parcels were deemed necessary by the EPA to respond to potential environmental and public health threats presented by contamination at the properties.

From 1915 to 1922, the W.L. Cummings Chemical Company of Lansdowne, Pennsylvania, processed radium using a refining technique developed by a University of Pennsylvania Physics Professor, Dr. Dicran Kabakjian. A by-product of the refining process was fine, well-graded sandlike tailings that were contaminated with naturally occurring radioactive elements, including radium-226 and thorium-230.

Local masonry and building contractors used these sandlike tailings as aggregate for work activities such as

- Laying mortar between brick and stone masonry,
- Pointing mortar on stone or brick masonry,
- Applying stucco to exteriors of houses,

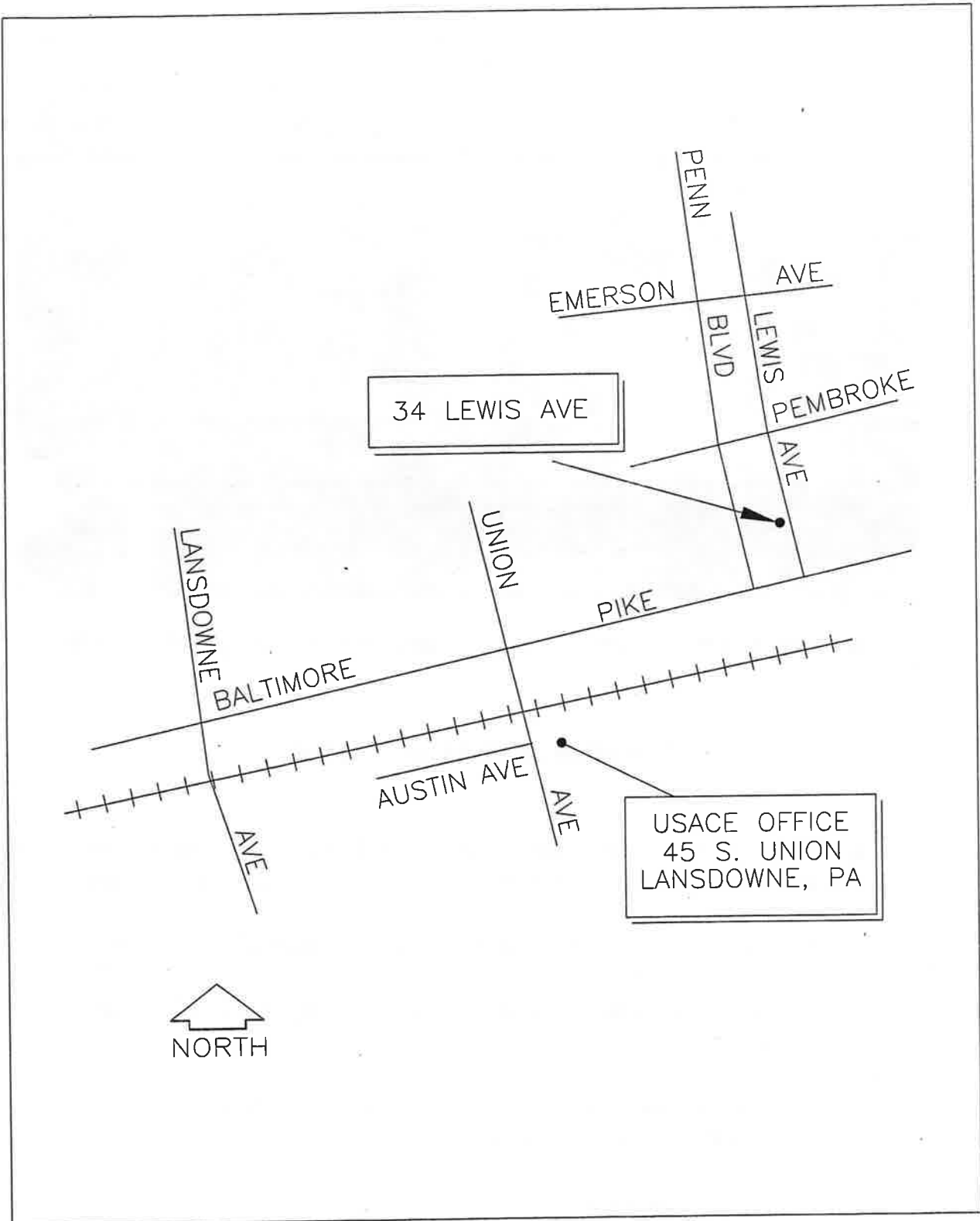
- Applying plaster to interiors of houses, and
- Layering concrete for sidewalks and basement slabs on grade.

The tailings were also used as fill under basement slabs, exterior perimeter foundation walls, and other miscellaneous applications. The tailings were used predominantly for the construction of new homes and for additions or repairs to existing homes. The extent of contamination includes, but is not limited to, perimeter load-bearing foundation walls, common party walls, firewalls, fireplaces and chimneys, brick support columns and piers, interior plaster, exterior stucco, backfill, and other uses associated with home construction.

Figure 2 is a map of the East Lansdowne area showing the location of the 34 Lewis Avenue property, and Figure 3 is a photograph of the property shortly before remediation activities began. The house on the 34 Lewis Avenue property was used as a single-family residence. The estimated extent and level of contamination at this property are described in detail in a characterization report prepared by Chem-Nuclear Systems, Inc. (1992). The report was prepared as part of the initial characterization efforts at the Austin Avenue Radiation Site. Prior to remedial action activities, contaminated areas at the 34 Lewis Avenue property included all basement walls, the soil under the basement floor, support pillars, the front sidewalk, and the front steps. The radium concentration in mortar samples ranged up to 1,052 pCi/g. In addition, approximately 257 yd<sup>3</sup> of soil was estimated to be contaminated with radium at concentrations ranging up to 75 pCi/g.

### 3 CLEANUP CRITERIA

The primary radioactive contaminants identified at the 34 Lewis Avenue property are radium-226 and thorium-230. The applicable cleanup criteria are specified in the Record of Decision for the Austin Avenue Radiation Site (U.S. Army Corps of Engineers [USACE] 1995) and summarized in the *Post-Cleanup Action Verification Plan* (Argonne National Laboratory [ANL] 1996). For soil, the cleanup criterion has been established as an activity concentration for radium-226 in dry soil of 5 pCi/g, including background. Because thorium-230 does not significantly add to the external radiation dose and because it is not a short-term source of radon (or of its decay products), the soil criterion for the property is based on radium only. Also, experience has shown that when a property is cleaned up so that the radium-226 concentration is less than 5 pCi/g, the thorium-230 concentration is also less than 5 pCi/g.



**FIGURE 2 Location of the 34 Lewis Avenue Property in East Lansdowne**

## 5 SUMMARY OF BASIS FOR VERIFICATION SURVEY

Following remedial action activities, the remediation contractor (Sevenson Environmental Services, Inc.) performed a final survey and submitted the results in a compliance report to the USACE. After Sevenson's final survey, an independent post-cleanup verification survey was performed by ANL for the USACE. The purpose of the verification survey was to confirm that the property at 34 Lewis Avenue was decontaminated to the radiological criteria established for the Austin Avenue Radiation Site (USACE 1995). The methods and procedures employed during the verification survey are described in detail in the *Post-Cleanup Action Verification Plan* (ANL 1996) and are summarized in Table 1. The verification plan includes a detailed discussion of applicable cleanup levels, equipment used, sampling methodologies, sample analyses, and quality control and assurance procedures.

The verification survey consisted of a property scan for gamma activity, followed by the collection and analysis of soil samples. Twenty-four soil samples were collected at the 34 Lewis Avenue property. The total number of samples was selected to demonstrate statistically that the cleanup criterion was satisfied at the 95% confidence level. Following collection, each soil sample was labeled relative to a fixed property coordinate system (sampling grid) and analyzed to determine the activity concentration of radium-226. The analytical results were then compared with the soil cleanup criterion of 5 pCi/g for radium-226 to determine if the criterion had been achieved.

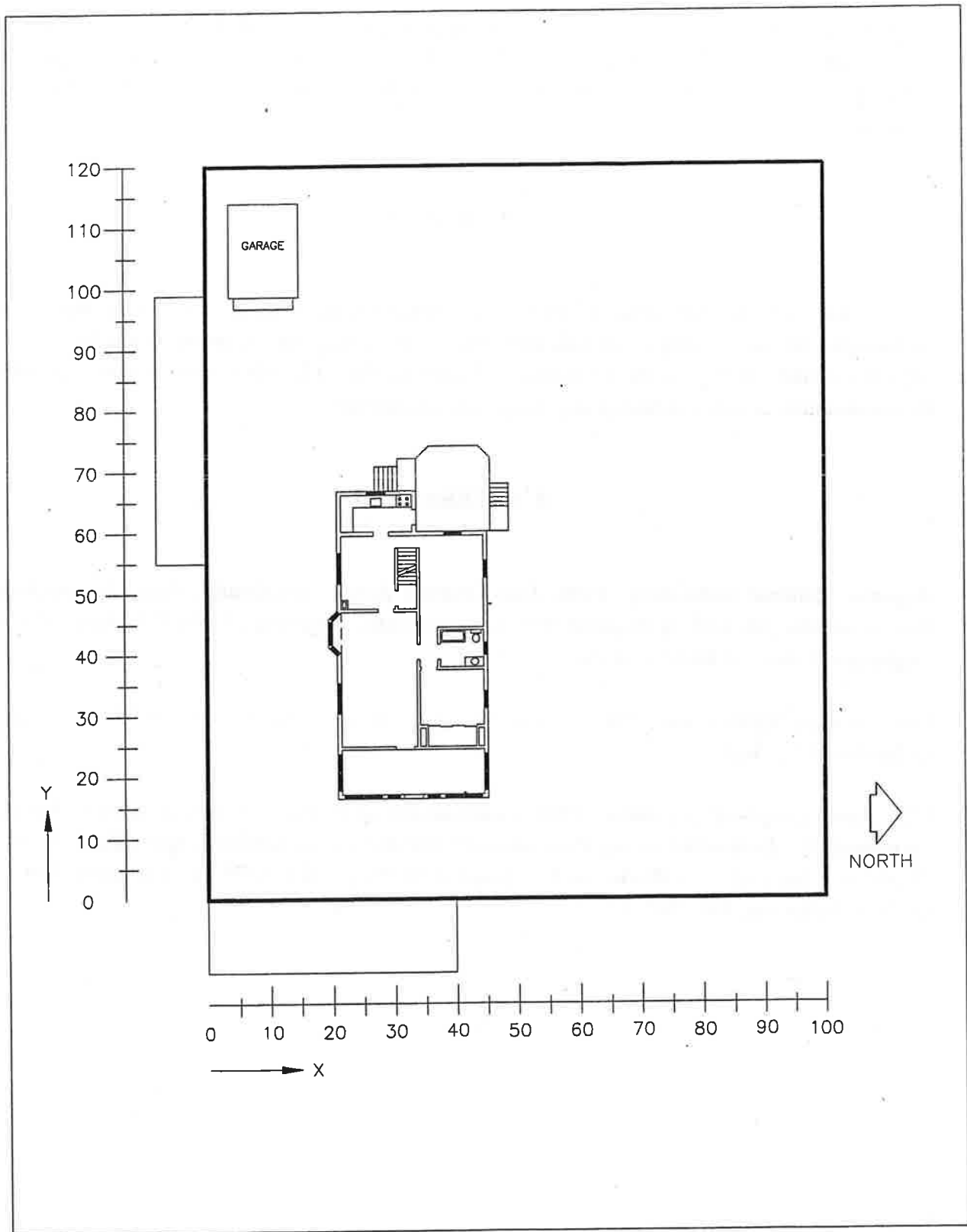
In situ measurements of the radium-226 concentrations were used as supplemental data to support the results obtained from soil sample analyses. Also, radiation exposure rate measurements were used as supplemental data to demonstrate that the mean exposure rate was typical of that found in uncontaminated areas of the community.

Figure 4 is a site map of the property overlain with the ANL coordinate system for sampling.

Additional contamination was found on the edge of the property at 28 Lewis Avenue, which is adjacent to 34 Lewis Avenue. Additional cleanup and verification were also performed on that site (shown as Blocks 22, 23, and 24 in Figure A.2).

## 6 RESULTS OF VERIFICATION SURVEY

The results of the verification survey, as well as a property map showing the coordinate system used for sample identification purposes, are described in detail in the Appendix. The full property gamma scan indicated that there were no anomalies remaining at the 34 Lewis Avenue



**FIGURE 4 Site Map of the Property at 34 Lewis Avenue Overlain with the ANL Coordinate System**

**APPENDIX:****DETAILED RESULTS OF VERIFICATION SURVEY  
AT 34 LEWIS AVENUE**

This appendix provides a summary of the data collected to support the verification survey conducted for the property at 34 Lewis Avenue. The methodologies and procedures used in the verification process are described in detail in the *Post-Cleanup Action Verification Plan* (Argonne National Laboratory 1996). The applicable cleanup criteria are specified in the Record of Decision for the Austin Avenue Radiation Site (U.S. Army Corps of Engineers 1995).

**A.1 FULL PROPERTY SCAN**

The property scan component consisted of scanning the entire property with a radiation detector to confirm that there were no localized areas of contamination that were significantly different from the average background radiation. The results of scans at the 34 Lewis Avenue property are listed in Table A.1. The data show that no anomalies were detected either by the "search" mode or by the comparative "integrate" mode. Property scan sections are shown in Figure A.1.

**A.2 SOIL SAMPLE ASSAYS**

Table A.2 lists the radium-226 concentration in 24 soil samples collected on an unaligned grid pattern (random samples within a systematic grid). The locations where the samples were collected are shown in Figure A.2 (a black dot within a circle indicates a split sample). The data show that the cleanup criterion of less than 5 pCi/g has been satisfied:

- Maximum concentration = 3.8 pCi/g dry soil.
- Mean concentration = 2.0 pCi/g dry soil.
- Standard deviation = 0.6 pCi/g dry soil.

The data also show that the two split samples analyzed for thorium-230 had concentrations less than 5 pCi of thorium-230 per gram (0.7 and 1.2 pCi/g).



- There is 95% confidence that the mean concentration of radium-226 at the 34 Lewis Avenue property is less than 2.2 pCi/g, i.e.,

$$\bar{x} + 1.71 s/\sqrt{n} \text{ (using } t \text{ distribution; for 24 samples),}$$

where  $n$  is the number of samples reported in Table A.2.

- There is 100% confidence that the mean concentration of radium-226 at the 34 Lewis Avenue property is less than 5 pCi/g, i.e.,

$$Z_c = (5 - \bar{x})/(s/\sqrt{n}),$$

where  $Z$  is the number of standard deviations that the mean concentration of the samples is below the cleanup criterion of 5 pCi/g. The confidence level,  $c$ , is determined by comparison with the statistical  $Z$  distribution.

- There is 95% confidence that the mean radiation exposure rate at the 34 Lewis Avenue property is less than 16  $\mu$ R/h, i.e.,

$$\bar{x} + 2.02 s/\sqrt{n} \text{ (using } t \text{ distribution; for six samples).}$$

On the basis of the results of the verification survey, radiological conditions at the property are in compliance with EPA risk-based cleanup criteria and standards for protection of human health, safety, and the environment. Therefore, the property is suitable for construction of a new house or any other unrestricted use.

TABLE A.1 (Cont.)

Scan No.	Section (Row) No.	Scan Time/ Section <sup>a</sup> (min)	Total Counts/ Section <sup>b</sup> (cts)	Gross Count Rate/ Section <sup>c</sup> (cts/min $\pm 2\sigma$ )	Anomaly Detected <sup>d</sup> (Yes, No)
34	16	3.0	3,600	1,200 $\pm$ 40	N
35	17	8.0	11,000	1,375 $\pm$ 26	N
36	17	2.1	2,300	1,095 $\pm$ 46	N

<sup>a</sup> Each section is approximately 6 ft wide by 120 ft long.

<sup>b</sup> When necessary, the response from each different mini Fidler instrument was normalized to one selected instrument.

<sup>c</sup> Includes background, which is typically 1,500–2,000 cpm for the mini Fidler detector (2-mm thick by 50-mm NaI detector).

<sup>d</sup> Anomaly defined as a small spot with a count rate approximately twice the general background.

<sup>e</sup> Section "0" is the adjacent property, 28 Lewis Avenue (the driveway area south of 34 Lewis), as shown in Figure A.1

**TABLE A.2 Radioactivity Concentrations in Verification Soil Samples at the 34 Lewis Avenue Property**

Sample No. <sup>a</sup>	Block No.	Coordinates X, Y, Z <sup>b</sup> (ft)	Sample Age (h)	pCi/g of soil as collected $\pm 2\sigma^c$			Water (%)	Radon Ingrowth (%)	Radium-226 <sup>d,e</sup> (pCi/g $\pm 2\sigma$ )	Thorium-230 (pCi/g $\pm 2\sigma$ )	Uranium-235 (pCi/g $\pm 2\sigma$ )
				@186 keV	@352 keV	@609 keV					
Q120-009	1	8, 17, 0.7	73	3.4 $\pm$ 1.3	1.1 $\pm$ 0.2	1.2 $\pm$ 0.2	18	92	1.6 $\pm$ 0.2		
Q120-010	2	29, 2, -0.1	80	3.7 $\pm$ 1.6	1.5 $\pm$ 0.2	1.4 $\pm$ 0.2	18	93	1.8 $\pm$ 0.2		
Q122-011A	3	54, 9, 3.1	—	—	—	—	—	—	2.3 $\pm$ 0.02	1.2 $\pm$ 0.1	<0.03
Q122-011B	3	54, 9, 3.1	427	4.1 $\pm$ 1.5	2.4 $\pm$ 0.2	2.1 $\pm$ 0.2	18	99	2.5 $\pm$ 0.3		
Q120-012	4	76, 12, 2.2	811	4.3 $\pm$ 1.9	1.2 $\pm$ 0.2	1.3 $\pm$ 0.2	18	99	1.6 $\pm$ 0.2		
Q120-013	5	8, 48, 0.8	80	3.7 $\pm$ 1.6	1.4 $\pm$ 0.2	1.4 $\pm$ 0.2	18	93	1.8 $\pm$ 0.2		
Q120-014	6	37, 36, -0.9	166	3.1 $\pm$ 1.3	1.1 $\pm$ 0.1	1.0 $\pm$ 0.1	18	96	1.3 $\pm$ 0.2		
Q120-015	7	53, 27, 2.4	800	3.2 $\pm$ 1.4	1.8 $\pm$ 0.2	1.7 $\pm$ 0.2	18	99	2.1 $\pm$ 0.3		
Q122-016A	8	88, 38, 2.9	801	4.3 $\pm$ 1.7	1.2 $\pm$ 0.2	1.2 $\pm$ 0.2	18	99	1.5 $\pm$ 0.3		
Q120-016B	8	88, 38, 2.9	—	—	—	—	—	—	1.2 $\pm$ 0.03	0.7 $\pm$ 0.1	<0.02
Q120-017	9	16, 57, 1.1	166	2.4 $\pm$ 2.8	1.3 $\pm$ 0.2	1.4 $\pm$ 0.2	18	96	1.8 $\pm$ 0.3		
Q120-018	10	41, 62, -0.5	166	2.5 $\pm$ 1.9	1.3 $\pm$ 0.2	1.2 $\pm$ 0.2	18	96	1.5 $\pm$ 0.2		
Q120-019	11	59, 65, 2.6	341	4.1 $\pm$ 1.7	1.8 $\pm$ 0.2	1.7 $\pm$ 0.2	18	98	2.1 $\pm$ 0.3		
Q120-020	12	86, 62, 3.6	705	4.4 $\pm$ 2.9	1.4 $\pm$ 0.3	1.5 $\pm$ 0.3	18	99	1.9 $\pm$ 0.3		
Q120-021	13	4, 82, 0.9	192	4.2 $\pm$ 1.7	1.9 $\pm$ 0.2	2.0 $\pm$ 0.2	18	97	2.5 $\pm$ 0.2		
Q120-022	14	39, 86, 1.1	27	4.9 $\pm$ 1.9	1.9 $\pm$ 0.2	2.1 $\pm$ 0.2	22	89	3.0 $\pm$ 0.3		
Q120-023	15	54, 92, 3.3	818	4.5 $\pm$ 1.8	1.7 $\pm$ 0.2	1.8 $\pm$ 0.2	18	99	2.3 $\pm$ 0.2		
Q120-024	16	80, 78, 3.5	726	1.5 $\pm$ 0.8	1.2 $\pm$ 0.2	1.4 $\pm$ 0.2	18	99	1.8 $\pm$ 0.2		
Q120-025	17	18, 101, 2.3	31	5.8 $\pm$ 1.6	1.9 $\pm$ 0.2	1.6 $\pm$ 0.2	18	89	2.2 $\pm$ 0.3		
Q120-026	18	36, 110, 3.7	145	5.2 $\pm$ 2.2	1.7 $\pm$ 0.2	2.0 $\pm$ 0.2	18	95	2.5 $\pm$ 0.3		
Q120-027	19	60, 117, 3.9	705	3.3 $\pm$ 2.7	1.0 $\pm$ 0.2	1.3 $\pm$ 0.2	18	99	1.6 $\pm$ 0.3		
Q120-028	20	86, 114, 4.0	705	3.8 $\pm$ 1.8	1.4 $\pm$ 0.2	1.4 $\pm$ 0.3	18	99	1.7 $\pm$ 0.3		
Q120-029	21	28, -6, 0.0	8	3.7 $\pm$ 1.8	1.1 $\pm$ 0.2	1.1 $\pm$ 0.1	18	87	1.5 $\pm$ 0.2		

**TABLE A.3 Results of In Situ Measurements of Radium-226 in Soil at the 34 Lewis Avenue Property<sup>a</sup>**

Measurement Location No. <sup>b</sup>	Count Time <sup>c</sup> (min)	At 186 keV Calibration Factor <sup>d</sup> = 3.74 cpm/pCi·g <sup>-1</sup>		At 352 keV Calibration Factor <sup>d</sup> = 26.7 cpm/pCi·g <sup>-1</sup>		At 609 keV Calibration Factor <sup>d</sup> = 24.8 cpm/pCi·g <sup>-1</sup>		At 1,764 keV Calibration Factor <sup>d</sup> = 5.25 cpm/pCi·g <sup>-1</sup>		Radium-226 (pCi/g ± 2σ)
		Count Rate (cpm)	pCi/g ± 2σ	Count Rate (cpm)	pCi/g ± 2σ	Count Rate (cpm)	pCi/g ± 2σ	Count Rate (cpm)	pCi/g ± 2σ	
1	20	15.2 ± 4.5	4.1 ± 2.4	51.9 ± 2.9	1.9 ± 0.2	48.6 ± 2.3	2.0 ± 0.2	8.8 ± 0.9	1.7 ± 0.4	1.9 ± 0.1
2	20	25.5 ± 4.4	6.8 ± 2.4	48.5 ± 2.9	1.8 ± 0.2	39.9 ± 2.2	1.6 ± 0.2	10.9 ± 0.8	2.1 ± 0.4	1.9 ± 0.1
3	20	11.3 ± 4.0	3.0 ± 2.2	32.5 ± 2.6	1.2 ± 0.2	27.1 ± 2.0	1.1 ± 0.2	6.3 ± 0.7	1.2 ± 0.2	1.2 ± 0.1
4	20	—	—	32.4 ± 2.6	1.2 ± 0.2	24.5 ± 1.9	1.0 ± 0.2	8.8 ± 0.7	1.7 ± 0.2	1.3 ± 0.1
5	20	10.9 ± 4.3	2.9 ± 2.2	36.3 ± 2.7	1.4 ± 0.2	33.9 ± 2.1	1.4 ± 0.2	8.1 ± 0.8	1.5 ± 0.2	1.4 ± 0.1
6	20	5.9 ± 4.4	1.6 ± 2.4	36.8 ± 2.8	1.4 ± 0.2	35.4 ± 2.1	1.4 ± 0.2	9.2 ± 0.9	1.7 ± 0.4	1.4 ± 0.1

Mean concentration = 1.5 pCi radium-226 per gram of soil.

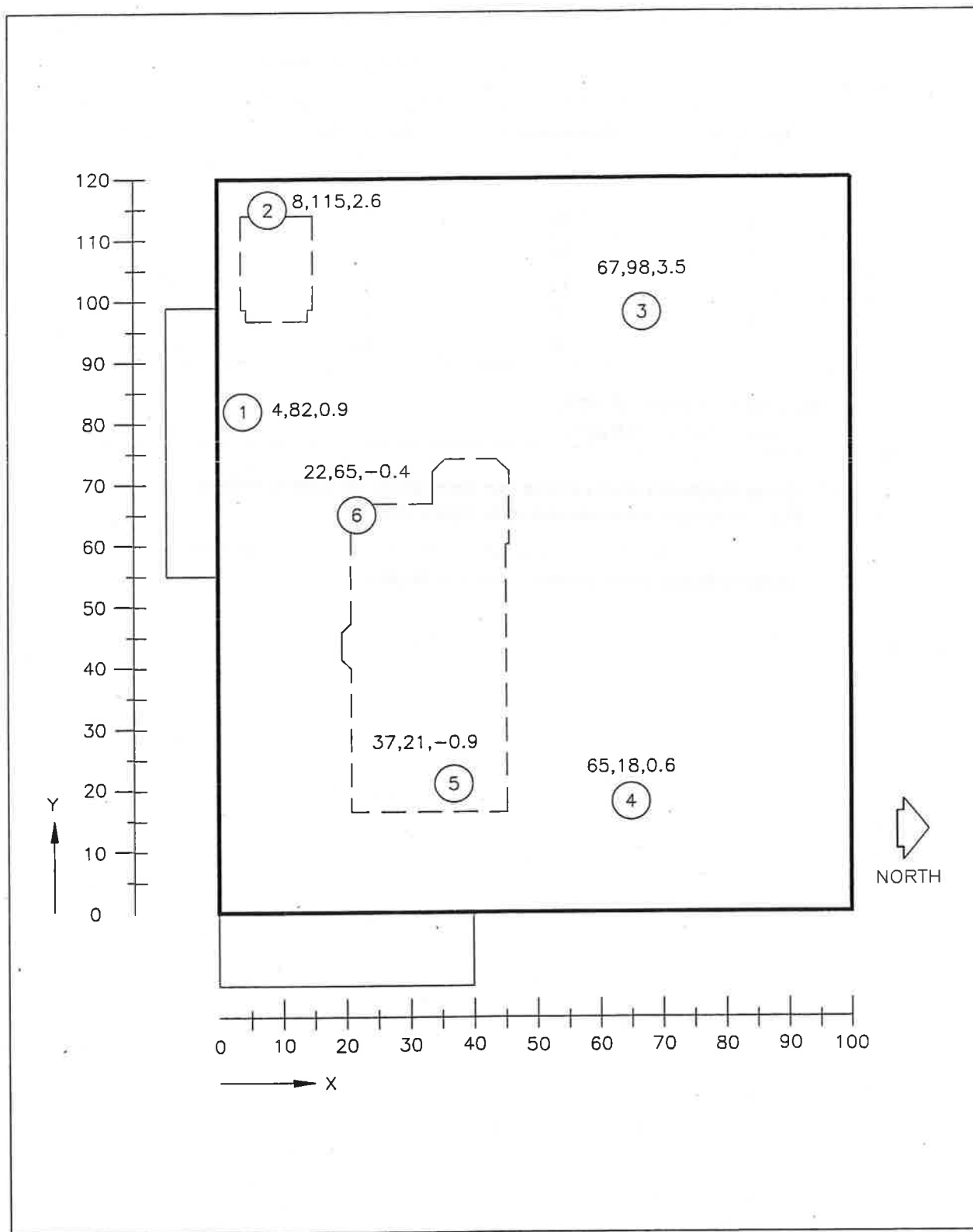
Standard deviation = 0.3 pCi radium-226 per gram of soil.

<sup>a</sup> Measurements were made with a HPGe detector placed one meter above ground.

<sup>b</sup> Measurement locations are shown in Figure A.3.

<sup>c</sup> A 1-μCi cobalt-60 button reference source was placed one meter below the detector (along its vertical axis) as a quality assurance check on detector efficiency during the entire count time for every measurement.

<sup>d</sup> Calibration factors based on Helfer and Miller (1988).



**FIGURE A.3 Randomly Selected Locations of In Situ Gamma Ray Spectroscopy for Determination of Average Radium-226 Concentrations in Soil at the 34 Lewis Avenue Property**

## REFERENCES FOR APPENDIX A

Argonne National Laboratory, 1996, *Post-Cleanup Action Verification Plan: Austin Avenue Radiation Site*, prepared by Argonne National Laboratory, Argonne, Ill., for U.S. Army Corps of Engineers, Baltimore District, Baltimore, Md.

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